

IN THE CLAIMS:

1 1. (PREVIOUSLY PRESENTED) A policer based on Random Early Detection (RED),
2 comprising:

3 a filter to determine a filtered virtual time debt, the filtered virtual time debt de-
4 termined based on an average difference between a time packets are expected to arrive
5 and a time the packets actually arrive; and

6 a control law circuit to receive the filtered virtual time debt from the filter and to
7 determine whether a packet should be dropped.

1 2. (PREVIOUSLY PRESENTED) The RED policer of claim 1, wherein a virtual time
2 debt is configured to use a time T in which a packet is expected to arrive and is computed
3 using a predetermined output transmission rate.

1 3. (ORIGINAL) The RED policer of claim 2, wherein predetermined output transmis-
2 sion rate is given by a traffic contract.

1 4. (PREVIOUSLY PRESENTED) The RED policer of claim 1, wherein the filter is
2 based on an exponential weighted moving average (EWMA) virtual time delay using the
3 expression,

4
$$EWMA_k = (1-g)EWMA_{k-1} + g(VTD)_k,$$

5 where k indicates the presently received packet, and k-1 indicates the last packet
6 received, the virtual time debt (VTD) is computed by the expression: $VTD = T(\text{packet}$
7 $\text{expected to arrive}) - T(\text{packet actually arrives})$, and g is the gain of the filter.

1 5. (PREVIOUSLY PRESENTED) The RED policer of claim 1, further comprising: a
2 sampler to sample a virtual time debt at a sampling interval, and to transmit the sampled
3 virtual time debt to the filter.

1 6. (PREVIOUSLY PRESENTED) The RED policer of claim 1, further comprising:
2 a random generator to generate a number based on the control law circuit's de-
3 termination as to whether a packet should be dropped; and
4 a counter configured to be set with the number generated by the random genera-
5 tor, wherein the counter is configured to count packets passing through the RED policer
6 up to the set number, and wherein the RED policer is configured to drop a packet when
7 the counter has counted out the set number.

1 7. (PREVIOUSLY PRESENTED) The RED policer of claim 6, further comprising:
2 the control law circuit to determine a probability of a packet being dropped based
3 on the filtered time debt exceeding a predetermined minimum threshold, and to specify a
4 range of numbers based on the probability; and
5 the random generator to randomly generate a number in the range specified by the
6 control law circuit.

1 8. (PREVIOUSLY PRESENTED) A policer based on Random Early Detection (RED),
2 comprising:
3 means for determining a moving average of a virtual time debt, the virtual time
4 debt determined based on a difference between a time packets are expected to arrive and
5 a time the packets actually arrive; and

6 means for determining whether a packet should be dropped based on a value of the
7 moving average of the virtual time debt.

1 9. (ORIGINAL) The RED policer of claim 8, further comprises means for sampling a
2 virtual time debt at a sampling interval, and transmitting the result to the moving average
3 determining means.

1 10. (ORIGINAL) The RED policer of claim 8, further comprises:

2 means for generating a random number based on the result of the packet dropping
3 means; and

4 means for counting a number of packets passing through the RED policer up to
5 the random number generated by the random number generating means, wherein the
6 RED policer drops a packet when the counting means has counted out the generated ran-
7 dom number.

1 11. (PREVIOUSLY PRESENTED) A network device comprising:

2 a plurality of Random Early Detection (RED) policers, wherein each RED policer
3 comprises,

4 a filter to determine a filtered virtual time debt, the filtered virtual time
5 debt determined based on an average difference between a time packets are ex-
6 pected to arrive and a time the packets actually arrive; and

7 a control law circuit to receive the filtered virtual time debt from the filter
8 and to determine whether a packet should be dropped; and

9 a packet classifier to determine which packet should go to which RED policer.

1 12. (PREVIOUSLY PRESENTED) A method of policing packets in a network device,
2 the method comprising the steps of:

3 determining a filtered virtual time debt of a traffic, the filtered virtual time debt
4 determined based on an average difference between a time packets of the traffic are ex-
5 pected to arrive and a time the packets actually arrive;

6 comparing the filtered virtual time debt with a predetermined minimum threshold;
7 and if the filtered virtual time debt exceeds the minimum threshold, then

8 generating a random number that is used to determine which packet should be
9 dropped.

1 13. (ORIGINAL) The method of claim 12, wherein generating a random number further
2 comprises the steps of:

3 generating the random number in a range based on a level by which the filtered
4 virtual time debt exceeds the minimum threshold;

5 setting a counter with the random number; and

6 dropping a packet when the counter has counted out the random number.

1 14. (PREVIOUSLY PRESENTED) A computer readable medium having instructions
2 contained therein, which when executed by a computer performs a method comprising
3 the steps of:

4 determining a filtered virtual time debt of a traffic, the filtered virtual time debt
5 determined based on an average difference between a time packets of the traffic are ex-
6 pected to arrive and a time the packets actually arrive;

7 comparing the filtered virtual time debt with a predetermined minimum threshold;
8 and if the filtered virtual time debt exceeds the minimum threshold, then

9 generating a random number that is used to determine which packet should be
10 dropped.

1 15. (ORIGINAL) The medium of claim 14, wherein generating a random number fur-
2 ther comprises the steps of:

3 generating the random number in a range based on a level the filtered virtual time
4 debt exceeds the minimum threshold;

5 setting a counter with the random number; and

6 dropping a packet when the counter has counted out the random number.

1 16. (CANCELLED)

1 17. (PREVIOUSLY PRESENTED) A method of policing packets in a network device,
2 the method comprising the steps of:

3 determining a filtered virtual time debt of packets flowing through the network
4 device, the filtered virtual time debt determined based on an average difference between a
5 time packets are expected to arrive and a time the packets actually arrive; and

6 determining whether a packet should be dropped based on the filtered virtual time
7 debt of the packets.

1 18. (PREVIOUSLY PRESENTED) The method as in claim 17, further comprising: de-
2 termining that a packet should be dropped when a virtual time debt threshold has been
3 reached.

1 19. (PREVIOUSLY PRESENTED) The method as in claim 17, further comprising: de-
2 termining a moving average of the virtual time debt.

1 20. (PREVIOUSLY PRESENTED) The method as in claim 17, further comprising:
2 calculating the virtual time debt as the difference between a time a packet is expected to
3 arrive and a time the packet actually arrives.

1 21. (PREVIOUSLY PRESENTED) The method as in claim 20, further comprising:
2 calculating the time a packet is expected to arrive according to a traffic contract.

1 22. (PREVIOUSLY PRESENTED) The method as in claim 17, further comprising:
2 sampling the virtual time debt at a sampling interval.

1 23. (PREVIOUSLY PRESENTED) The method as in claim 17, further comprising:
2 generating a random number;
3 counting a number of packets passing through the network device up to the ran-
4 dom number; and
5 dropping a packet when the counted number reaches the random number.

1 24. (PREVIOUSLY PRESENTED) A method of policing packets in a network device,
2 the method comprising the steps of:

3 determining a filtered virtual time debt of packets flowing through the network
4 device, the filtered virtual time debt computed as an average positive delay from an ex-
5 pected packet arrival time established by a traffic contract to an actual packet arrival
6 time;

7 determining that packets should be dropped when the filtered virtual time debt of
8 the packets exceeds a predetermined value; and if so

9 choosing a packet to be dropped, the chosen packet in response to a random num-
10 ber; and

11 dropping the chosen packet.

1 25. (PREVIOUSLY PRESENTED) The method as in claim 24, further comprising:

2 generating the random number;

3 counting a number of packets passing through the network device up to the ran-
4 dom number; and

5 dropping a packet when the counted number reaches the random number.

1 26. (PREVIOUSLY PRESENTED) A policer, comprising:

2 means for determining a filtered virtual time debt of packets flowing through the
3 network device, the virtual time debt computed as an average positive delay from an ex-
4 pected packet arrival time established by a traffic contract to an actual packet arrival
5 time;

6 means for determining that packets should be dropped when the virtual time debt
7 of the packets exceeds a predetermined value; and if so

8 means for choosing a packet to be dropped, the chosen packet in response to a
9 random number; and

10 means for dropping the chosen packet.

1 27. (PREVIOUSLY PRESENTED) A computer readable media, the computer readable
2 media containing instructions for execution in a processor for the practice of the method
3 comprising the steps of:

4 determining a filtered virtual time debt of packets flowing through the network
5 device, the filtered virtual time debt determined based on an average difference between a
6 time packets are expected to arrive and a time the packets actually arrive; and

7 determining whether a packet should be dropped based on the filtered virtual time
8 debt of the packets.

1 28. (CANCELLED).

1 29. (PREVIOUSLY PRESENTED) A method of policing packets in a network device,
2 the method comprising the steps of:

3 determining a filtered virtual time debt of packets flowing through the network
4 device, the filtered virtual time debt computed as an average positive delay from an ex-
5 pected packet arrival time to an actual packet arrival time; and

6 determining whether a packet should be dropped based on the filtered virtual time
7 debt of the packets.

1 30. (PREVIOUSLY PRESENTED) The method as in claim 29, in the event a packet
2 should be dropped, further comprising:

3 generating a random number;

4 counting a number of packets passing through the network device up to the ran-
5 dom number; and

6 dropping a packet when the counted number reaches the random number.

1 31. (PREVIOUSLY PRESENTED) A method of policing packets in a network device,
2 comprising:

3 determining an actual arrival time of a packet;

4 determining a theoretical arrival time of the packet;

5 calculating a virtual time debt in response to the actual arrival time and the theo-
6 retical arrival time;

7 using a filter to determine a filtered virtual time debt of a traffic, the filtered vir-
8 tual time debt determined based on an average of a plurality of virtual time debts for the
9 traffic;

10 comparing the filtered virtual time debt with a predetermined value;

11 deciding if the filtered virtual time debt exceeds the predetermined value; and

12 generating, in response to the filtered virtual time debt exceeding the predeter-
13 mined value, a random number that is used to determine which packet should be dropped.

1 32. (CANCELLED)

1 33. (PREVIOUSLY PRESENTED) The method of claim 31, further comprising:

2 computing a predetermined output transmission rate.

1 34. (PREVIOUSLY PRESENTED) The method of claim 33, further comprising:

2 setting the predetermined output transmission rate by a traffic contract.

1 35. (PREVIOUSLY PRESENTED) The method of claim 31, further comprising:

2 sampling the virtual time debt at a sampling interval; and
3 transmitting the sampled virtual time debt to the filter.

1 36. (PREVIOUSLY PRESENTED) The method of claim 31, further comprising:

2 using a counter that is set with the generated random number;
3 counting packets passing through a RED policer up to the set number;
4 dropping the packet when the counter has counted out the set number.

1 37. (PREVIOUSLY PRESENTED) The method of claim 31, further comprising:

2 determining a moving average for the filtered virtual time debt.

1 38. (PREVIOUSLY PRESENTED) A policer based on Random Early Detection (RED),
2 comprising:

3 an operating system to determine an actual arrival time of a packet and a theoreti-
4 cal arrival time of the packet;

5 a control law circuit to i) calculate a virtual time debt in response to the actual ar-
6 rival time and the theoretical arrival time,

7 a filter to determine a filtered virtual time debt of a traffic, the filtered virtual time
8 debt determined based on an average of a plurality of virtual time debts for the traffic;

9 the control law circuit further to ii) compare the filtered virtual time debt with a
10 predetermined value, and iii) decide if the filtered virtual time debt exceeds the predeter-
11 mined value; and

12 a random number generator to generate, in response to the filtered virtual time
13 debt exceeding the predetermined value, a random number that is used to determine
14 which packet should be dropped.

1 39. (CANCELLED)

1 40. (PREVIOUSLY PRESENTED) The policer of claim 38, further comprising:

2 the filtered virtual time debt is configured to use time T in which the packet is ex-
3 pected to arrive, and is computed using a predetermined output transmission rate.

1 41. (PREVIOUSLY PRESENTED) The policer of claim 40, further comprising:

2 the predetermined output transmission rate is given by a traffic contract.

1 42. (PREVIOUSLY PRESENTED) The policer of claim 38, further comprising:

2 a sampler to sample the virtual time debt at a sampling interval and to transmit the
3 sampled virtual time debt to the filter.

1 43. (PREVIOUSLY PRESENTED) The policer of claim 38, further comprising:

2 a counter configured to be set with the number generated by the random number
3 generator, and configured to count packets passing through the RED policer up to the set
4 number; and

5 the RED policer configured to drop the packet when the counter has counted out
6 the set number.

1 44. (PREVIOUSLY PRESENTED) The policer of claim 38, further comprising:
2 the filter further to determine a moving average for the filtered virtual time debt.

1 45. (PREVIOUSLY PRESENTED) An apparatus for policing packets in a network de-
2 vice, comprising:

3 means for determining an actual arrival time of a packet;

4 means for determining a theoretical arrival time of the packet;

5 means for calculating a virtual time debt in response to the actual arrival time and
6 the theoretical arrival time;

7 means for using a filter to determine a filtered virtual time debt of a traffic, the fil-
8 tered virtual time debt determined based on an average of a plurality of virtual time debts
9 for the traffic;

10 means for comparing the filtered virtual time debt with a predetermined value;

11 means for deciding if the filtered virtual time debt exceeds the predetermined
12 value; and

13 means for generating, in response to the filtered virtual time debt exceeding the
14 predetermined value, a random number that is used to determine which packet should be
15 dropped.

1 46. (CANCELLED)

1 47. (PREVIOUSLY PRESENTED) The apparatus of claim 45, further comprising:

2 means for computing a predetermined output transmission rate.

1 48. (PREVIOUSLY PRESENTED) The apparatus of claim 47, further comprising:
2 means for setting the predetermined output transmission rate by a traffic contract.

1 49. (CANCELLED)

1 50. (PREVIOUSLY PRESENTED) The apparatus of claim 45, further comprising:
2 means for using a counter that is set with the number generated by the random
3 number generator;
4 means for counting packets passing through a RED policer up to the set number;
5 means for dropping the packet when the counter has counted out the set number.

1 51. (PREVIOUSLY PRESENTED) The apparatus of claim 45, further comprising:
2 means for determining a moving average for the filtered virtual time debt.

1 52. (PREVIOUSLY PRESENTED) A computer readable medium having instructions
2 contained therein, which when executed by a computer performs a method comprising
3 the steps of:
1 determining an actual arrival time of a packet;
2 determining a theoretical arrival time of the packet;
3 calculating a virtual time debt in response to the actual arrival time and the theo-
4 retical arrival time;
5 using a filter to determine a filtered virtual time debt of a traffic, the filtered vir-
6 tual time debt determined based on an average of a plurality of virtual time debts for the
7 traffic;

8 comparing the filtered virtual time debt with a predetermined value;
9 deciding if the filtered virtual time debt exceeds the predetermined value; and
10 generating, in response to the filtered virtual time debt exceeding the predeter-
11 mined value, a random number that is used to determine which packet should be dropped.

1 53. (CANCELLED)

2 54. (PREVIOUSLY PRESENTED) The RED policer of claim 1, further comprising: the
3 filter further configured to calculate the average as an exponential weighted moving aver-
4 age (EWMA).

1 55. (PREVIOUSLY PRESENTED) The RED policer of claim 8, further comprising:
2 means for calculating the average as an exponential weighted moving average (EWMA).

1 56. (PREVIOUSLY PRESENTED) The network device of claim 11, further compris-
2 ing: the filter further configured to calculate the average as an exponential weighted mov-
3 ing average (EWMA).

1 57. (PREVIOUSLY PRESENTED) The method of claim 12, further comprising: calcu-
2 lating the average as an exponential weighted moving average (EWMA).

1 58. (PREVIOUSLY PRESENTED) The medium of claim 14, further comprising the
2 step of: calculating the average as an exponential weighted moving average (EWMA).

1 59. (PREVIOUSLY PRESENTED) The method of claim 17, further comprising: calcu-
2 lating the average as an exponential weighted moving average (EWMA).

1 60. (PREVIOUSLY PRESENTED) The method of claim 24, further comprising: calcu-
2 lating the average as an exponential weighted moving average (EWMA).

1 61. (PREVIOUSLY PRESENTED) The policer of claim 26, further comprising: means
2 for calculating the average as an exponential weighted moving average (EWMA).

1 62. (PREVIOUSLY PRESENTED) The medium of claim 27, further comprising the
2 step of: calculating the average as an exponential weighted moving average (EWMA).

1 63. (PREVIOUSLY PRESENTED) The method of claim 29, further comprising: calcu-
2 lating the average as an exponential weighted moving average (EWMA).

1 64. (PREVIOUSLY PRESENTED) The method of claim 31, further comprising: calcu-
2 lating the average as an exponential weighted moving average (EWMA).

1 65. (PREVIOUSLY PRESENTED) The policer of claim 38, further comprising: the fil-
2 ter further configured to calculate the average as an exponential weighted moving aver-
3 age (EWMA).

1 66. (PREVIOUSLY PRESENTED) The apparatus of claim 45, further comprising:
2 means for calculating the average as an exponential weighted moving average (EWMA).

- 1 67. (PREVIOUSLY PRESENTED) The medium of claim 52, further comprising the
- 2 step of: calculating the average as an exponential weighted moving average (EWMA).